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INNOVATIVE TECHNOLOGIES FOR FROZEN SEMI-FINISHED PRODUCTS FROM APPLES WITH REDUCED ENERGY VALUE

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Abstract

Freezing is an effective way to preserve the quality of fruit and vegetable products and is widely used for the production of quick-frozen foods, semi-finished products and ready-to-eat meals. However, the quality of frozen products can undergo undesirable changes that can be prevented by pretreatment. The aim of the study was to evaluate the effect of a polysaccharide coating of pectin solution of different concentrations on the physicochemical properties of partially osmotically dehydrated frozen semi-finished apple products. Jonagold (Wilmuta) apples were peeled, core removed, and cut into 20×20 mm slices, blanched in a 0.1 % citric acid solution at 85 °C for 2–5 min, dried, and immersed in a pectin solution with a concentration of 1, 2, 3, 4, 5 %, followed by drying. The prepared apple particles were kept for 30 min in a 30 % aqueous sucrose solution before freezing. Uncoated apple particles were used as a control. The apples were frozen in bulk at minus 30 ± 1°C, packed in plastic film bags, and stored for 6 months at minus 18±1 °C. The application of a food coating from a pectin solution to apple semi-finished products before partial osmotic dehydration and freezing inhibited the increase in dry soluble substances during dehydration by 1.4–2.0 %. The cryoresistance of the semi-finished product samples was recorded at 87.9–95.8 %, with an increase in the values of the studied indicator by 0.8–7.9 % in the coated samples. The use of a food coating made of a pectin solution contributed to a decrease in product weight loss during freezing by 0.2–1.1 % and dry soluble substances by 0.2–0.4 %. The presence of the food coating had a positive effect on the appearance and consistency of the semi-finished products. Semi-finished products with food coating in a pectin solution of 5 % concentration were of better quality.

Keywords: edible coating; osmotic dehydration; freezing; semi-finished apple products; quality.

ІННОВАЦІЙНІ ТЕХНОЛОГІЇ ЗАМОРОЖЕНИХ НАПІВФАБРИКАТІВ ІЗ ЯБЛУК ЗНИЖЕНОЇ ЕНЕРГЕТИЧНОЇ ЦІННОСТІ

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Анотація

Заморожування є ефективним способом збереження якості плодоовочевої продукції та широко використовується для виробництва швидкозаморожених продуктів, напівфабрикатів і готових страв. Однак якість замороженої продукції може зазнавати небажаних змін, запобігти яким можна за допомогою попередньої обробки. Мета роботи полягала в оцінюванні впливу полісахаридного покриття з розчину пектину різної концентрації на фізико-хімічні властивості частково осмотично дегідратованих заморожених напівфабрикатів з яблук. Яблука сорту Джонаголд (Вілмута) очищували від шкірки, видаляли серцевину та різали на частинки розміром 20х20 мм, бланшували у 0.1% розчині лимонної кислоти за температури 85 °С впродовж 2–5 хв, підсушували та занурювали у розчин пектину з концентрацією 1, 2, 3, 4, 5 % з наступним підсушуванням. Підготовлені частинки яблук перед заморожуванням витримували впродовж 30 хв у 30 %-му водному розчині сахарози. За контроль приймали частинки яблук без покриття. Яблука заморожували розсипом за температури –30 ± 1 °С, фасували у пакети з поліетиленової плівки і зберігали впродовж 6-ти місяців за температури –18 ± 1°С. Нанесення харчового покриття з розчину пектину на напівфабрикати з яблук перед частковою осмотичною дегідратацією та заморожуванням гальмувало приріст в них сухих розчинних речовин впродовж дегідратації на 1.4–2.0 %. Кріорезистентність зразків напівфабрикатів зафіксована на рівні 87.9–95.8 %, за підвищення значень досліджуваного показника на 0.8–7.9 % у зразках з покриттям. Застосування харчового покриття з пектинового розчину сприяло зниженню втрат маси продукції під час заморожування на 0.2–1.1 % та сухих розчинних речовин – на 0.2–0.4 %. Наявність харчового покриття справило позитивний вплив на зовнішній вигляд та консистенцію напівфабрикатів. Кращої якості отримані напівфабрикати з харчовим покриттям у розчині пектину 5 %-вої концентрації.

Ключові слова: їстівне покриття; осмотична дегідратація; заморожування; напівфабрикати; якість

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Introduction

Fruits and vegetables play an important role in a healthy diet and are high on the list of consumer priorities. The World Health Organization recommends a daily intake of 400 g of fruit and vegetables per day [1], while the actual consumption of fruits and vegetables in Ukraine does not exceed 50 % of the physiological norms [2].

Despite the undeniable health benefits, maintaining quality, extending shelf life and ensuring microbiological safety of such perishable products is an important task. At the same time, changes in consumer behavior and tastes with an emphasis on leading a healthy lifestyle with reduced calories and increased dietary fiber consumption encourage the search for innovations in food production that are harmonized with the requirements and expectations of consumers [3].

An effective way to preserve the quality of fruit and vegetable products is to use freezing with the expansion of the range of quick-frozen products, semi-finished products and ready-to-eat meals [4]. Freezing inhibits the growth of pathogenic microflora and the passage of undesirable chemical reactions that cause food spoilage [5–7]. However, the quality of frozen products can change under the influence of low temperatures, causing changes in consistency, color and increased losses of chemical composition components [8]. Pre-treatment of products before freezing prevents undesirable changes in product quality.

Partial loss of moisture from plant tissues by immersion in a hypertonic (osmotic) solution is used in the food industry as a method of pretreatment of raw materials [8]. Dehydration is caused by the difference in the chemical potential of water between the product and the osmotic medium. During dehydration, multidirectional mass transfer occurs due to the transfer of water from the material to the osmotic solution, and at the same time the penetration of the osmotic substance into the dehydrated tissue. Low molecular weight substances, such as vitamins, organic acids, saccharides, or mineral salts, are washed out of the tissue [9]. Solutions of monosaccharides (glucose, fructose), disaccharides (sucrose, maltose), polysaccharides (starch), inorganic salts (sodium chloride, potassium chloride) and high molecular weight osmotic agents (maltodextrin, gelatin, albumin, polypeptides, corn syrup and glycerin) can be used as osmotic agents in the dehydration process [10]. Sucrose is the most popular osmotic agent [11; 12].

The result of osmotic dehydration is the creation of food products with intermediate humidity with reduced water activity, which significantly inhibits chemical, biological and physical processes that cause food spoilage, thereby extending their shelf life [13], reducing the load on freezing without causing changes in product consistency [14]. In addition, the process of osmotic dehydration is used as a method of enriching fruits with healthy substances [15]. For example, the positive effect of osmotic dehydration in solutions of sucrose, glucose and maltose [16; 17], maltose and isomalt oligosaccharides [18], fructose [19] on the quality of sliced apples, including frozen ones [20], has been proven.

Despite the positive effect on product quality, scientists report a significant increase in sugar in fruits and berries during osmotic dehydration in sucrose solutions [21]. Instead, consumers prefer food products with reduced sugar content due to its negative impact on health [22]. In addition, it has been proven that under certain conditions of osmotic dehydration, significant amounts of solute absorption and greater changes in the components of the chemical composition of fruits and berries can negatively affect the sensory and nutritional properties of products, especially when exposed to high temperatures and long processing times [23].

An effective method of preventing sugar increase in products and improving their quality is the use of barrier technologies and combined methods with coating. Coatings have not only barrier properties against external influences, but are also used as carriers of food additives for antimicrobial protection, improving the appearance, consistency and taste of products. Edible coatings are developed using biobased polymers such as starches, proteins, lipids, gums or cellulose derivatives, which are made from various agricultural products. The main characteristics of coatings are edibility, biocompatibility, and barrier properties [24].

The effectiveness of edible barrier coatings has also been studied in osmotic dehydration processes in order to prevent the penetration of dissolved substances into raw materials while maintaining the rate of moisture removal [25]. For example, the study of the application of a combined edible coating (alginate and pectin) and the process of osmotic dehydration in a glucose solution at 40 °Brix and 60 °Brix on the quality of pear cubes showed higher values of moisture loss and lower rates of increase in the level of dry soluble substances than in uncoated samples [26]. Edible coatings made of corn starch have been shown to significantly reduce the absorption of dry soluble substances during the dehydration process of sliced carrots [27].

Mohammadkhani M., Koocheki A., Mohebbi M. [28] reported that the use of Lepidium perfoliatum gum seeds as a coating improved the properties of osmotically dehydrated apples. According to Rodriguez A., Soteras M., Campañone L. [29], the application of edible coatings (sodium alginate and low methoxyl pectin) resulted in greater strength and stiffness of pear dice as a result of osmotic dehydration.

It was found that quince pieces coated with guar gum had a lower content of dry soluble substances than uncoated samples, and its decrease was observed with an increase in the concentration of guar gum from 0.05 % to 0.15 % [30].

According to Jalaee F., Fazeli A., Fatemian H., Tavakolipour H. [31], coatings of carboxylmethyl cellulose, low-methoxylated pectin, and corn starch on apple samples helped to reduce the increase in dry soluble solids without significantly affecting the release of moisture.

Improving the technology of frozen semi-finished products from fruits and berries with reduced energy value and improved organoleptic properties will help to meet consumer needs. The use of a polysaccharide coating as a barrier to inhibit sucrose growth will reduce the sugar content of frozen fruit and berry products and expand the range of products with functional properties.

The aim of our work was to evaluate the effect of a polysaccharide coating made from a pectin solution of different concentrations on the physicochemical properties of partially osmotically dehydrated frozen semi-finished apple products.

Experimental part

The study was conducted with apples of the Jonagold variety (Wilmuta). Apples were peeled, core removed, and cut into 20×20 mm slices. The sliced apples were blanched in a 0.1 % citric acid solution at 85 °C for 2–5 minutes to prevent darkening of the product, followed by air drying. To make the coating, low-methoxylated citrus pectin was dissolved in distilled water to obtain solutions with a concentration of 1, 2, 3, 4, 5 %. The prepared apple particles were immersed in the pectin solution and then dried to remove excess solution. The coated apple particles were kept for 30 min in a 30 % aqueous sucrose solution before freezing. Uncoated apple particles were used as a control.

The partially osmotically dehydrated apple particles were frozen in bulk at minus 30±1 °C, packed in 0.5 kg plastic film bags intended for food packaging, and stored for 6 months at minus 18±1 °C.

In semi-finished products, cryoresistance was determined by the difference in the mass of frozen and defrosted product samples, and mass loss was determined by the difference in the mass of a fixed sample before and after freezing and expressed as a percentage. The increase in dry soluble substances was calculated by the difference in their content before and after partial osmotic dehydration. The values of the studied parameters were recorded after freezing, three and six months of storage. The experiment was repeated three times.

Results and discussion

The study revealed a statistically significant effect of coating with pectin solution on the increase of dry soluble substances in apple particles due to partial osmotic dehydration in sucrose solution (Fig. 1).

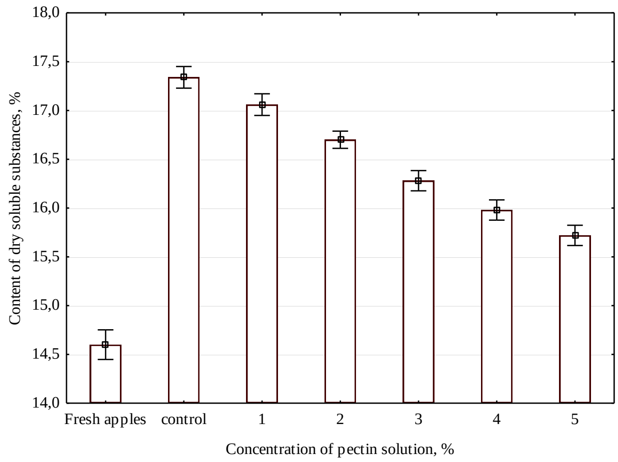

Fig. 1. The content of dry soluble substances in fresh and partially osmotically dehydrated semi-finished apple products depending on the concentration of pectin solution, %

Apples of the Jonagold variety (Wilmuta) accumulated 14.6 % of dry soluble solids. According to the averaged data, as a result of partial osmotic dehydration, the value of the studied indicator increased by 1.1–2.6 % with a minimal increase in apple particles coated with a 5 % pectin solution, which is 1.5 % lower compared to the uncoated sample. The data obtained are explained by the formation of a film

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on the surface of apple samples that has barrier properties to the penetration of sucrose solution into the product.

The ability of frozen fruit and vegetable products to retain moisture is characterized by the cryoresistance index, which depends on the anatomical structure of the raw material tissues and the content of dry matter in it.

The cryoresistance of the studied apple samples was recorded at the level of 87.9–95.8 %, with a maximum value of the studied indicator in the sample coated in a 5 % pectin solution, which was 7.9 % higher than the value of the control variant of the experiment (Fig. 2).

The application of the food coating resulted in an increase in the cryoresistance of the products by 0.8–7.9 %. A significant dependence of the values of the studied indicator on the concentration of the pectin solution before freezing was found: an increase in the concentration of the solution contributed to better moisture retention by the defrosted products, which is due to the barrier properties of the film on the surface of the product.

During the six months of storage in the frozen state, the value of the cryoresistance index of frozen products gradually decreased and by the end of this period amounted to 82.4–91.4 %, depending on the experimental variant, with a minimum value in the control after six months of storage. Semi-finished products treated in a pectin solution with a concentration of 5 % retained high values of the studied index.

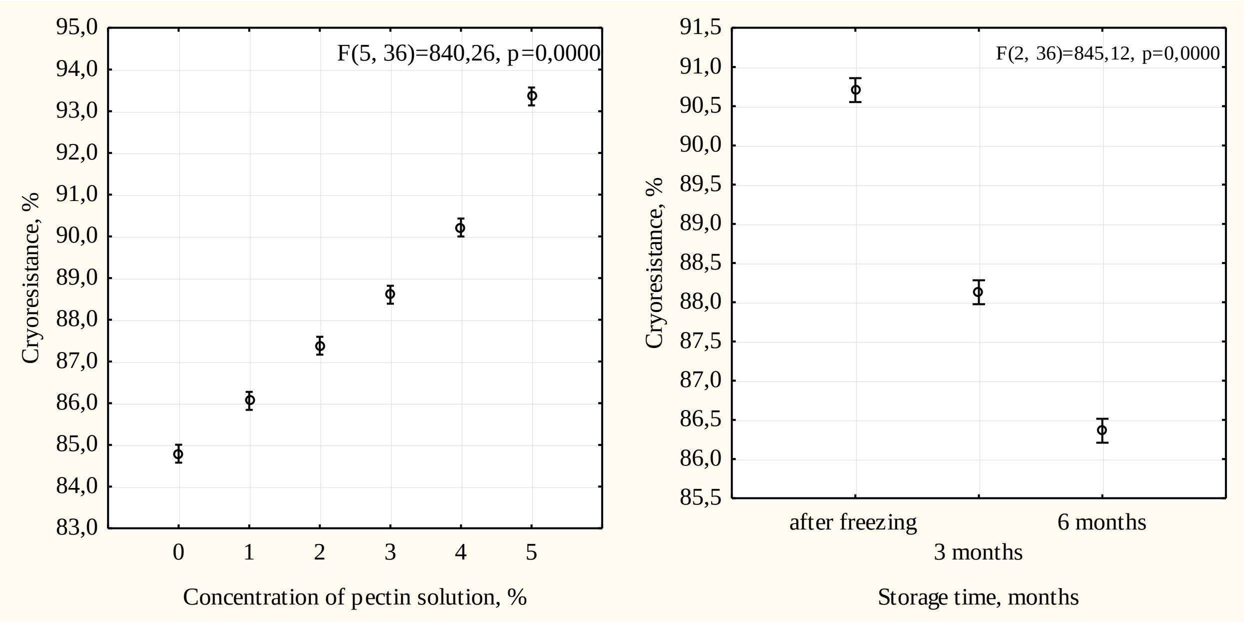

Fig. 2. Cryoresistance of partially osmotically dehydrated frozen semi-finished products from apples depending on: a – concentration of pectin solution, b – storage time, % (results of dispersion analysis)

Studies of weight loss of partially osmotically dehydrated frozen semi-finished apple products due to freezing and storage show significant differences in the values of this indicator depending on the concentration of the pectin solution and long-term storage (Fig. 3).

As a result of freezing, partially osmotically dehydrated semi-finished apple products lost 1.2–2.3 % of their weight, with the highest losses in the control. The use of a food coating made of pectin solution significantly reduced losses by 0.2–1.1 %, depending on the concentration of the pectin solution. During the six months of storage of apple semi-finished products in plastic film bags, weight losses amounted to 0.5–0.6 % and did not differ statistically.

According to the results of dispersion analysis, the content of dry soluble substances in frozen apple semi-finished products significantly depended on the concentration of pectin solution and storage time (Fig. 4). As a result of freezing, the content of dry soluble substances in semi-finished products decreased by 0.4–0.6 % with significant changes in the control. The use of coatings of different concentrations reduced losses by 0.2–0.4 %. During the long-term storage of apple semi-finished products, the content of dry soluble substances in them gradually decreased due to the recrystallization of moisture and by the end of the storage period reached the level of 15.0–16.2 %.

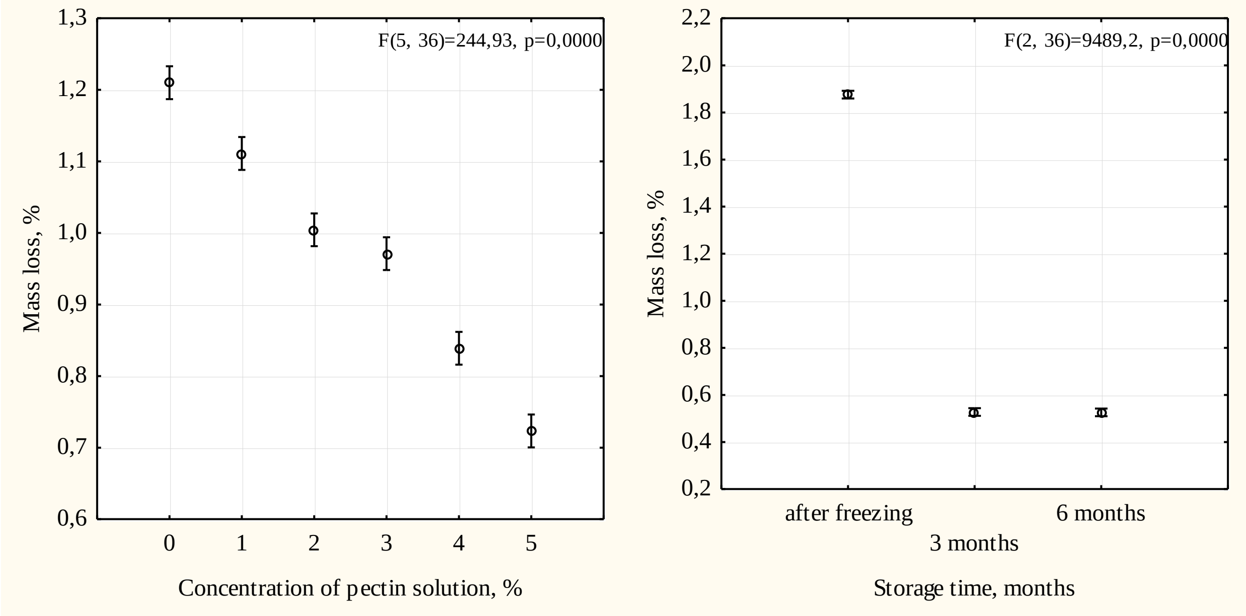

Fig. 3. Weight loss of partially osmotically dehydrated frozen semi-finished apple products depending on: a – concentration of pectin solution, b – storage time, % (results of dispersion analysis)

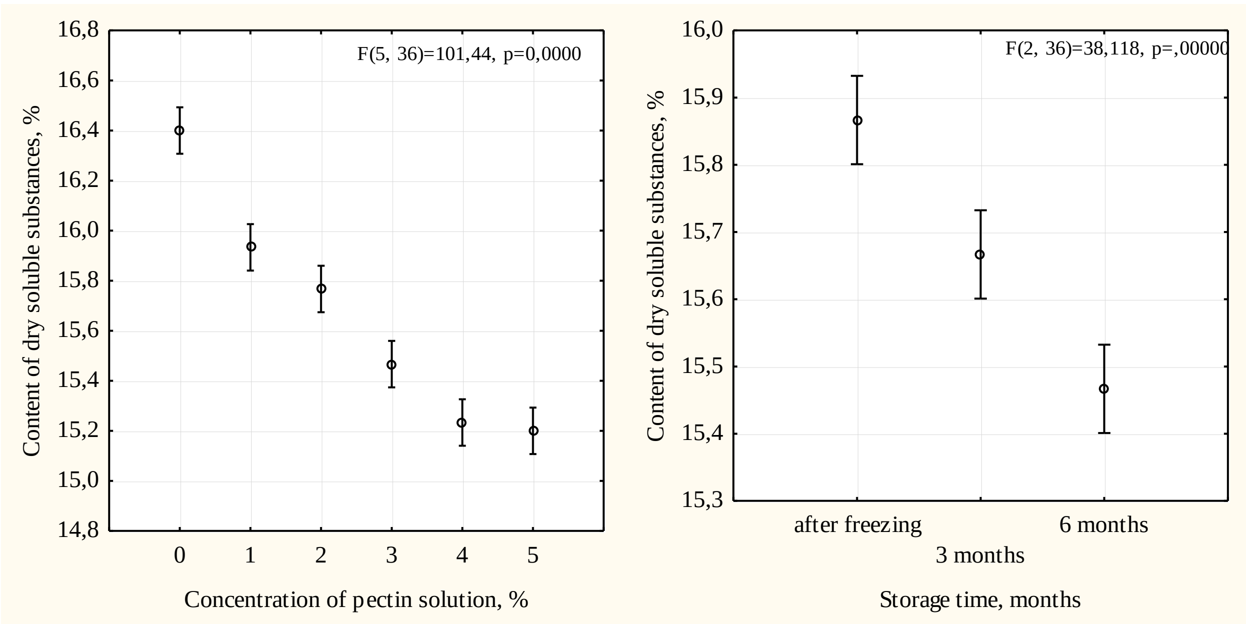

Fig. 4. The content of dry soluble substances of partially osmotically dehydrated frozen semi-finished products from apples as a function of: a – concentration of pectin solution, b – storage time, % (results of dispersion analysis)

In order to objectively determine the optimal values of cryoresistance for frozen semi-finished apple products, the method of estimating the predicted values and constructing a desirability function by weight loss and pectin solution concentration was used (Fig. 5). The minimum permissible value of cryoresistance was set at 88 % and the maximum at 95 %.

According to the results obtained, in order to maintain the cryo-resistance of frozen semi-finished apple products at 90.7 % with a weight loss not exceeding 1.87 %, the concentration of the pectin solution for coating semi-finished products should be at least 2.5 %. In this case, the requirements set for the model are met by 64 %.

The tasting of partially osmotically dehydrated frozen semi-finished products from food-coated apples in a pectin solution showed significant differences between the experimental variants depending on the concentration of the pectin solution (Fig. 6).

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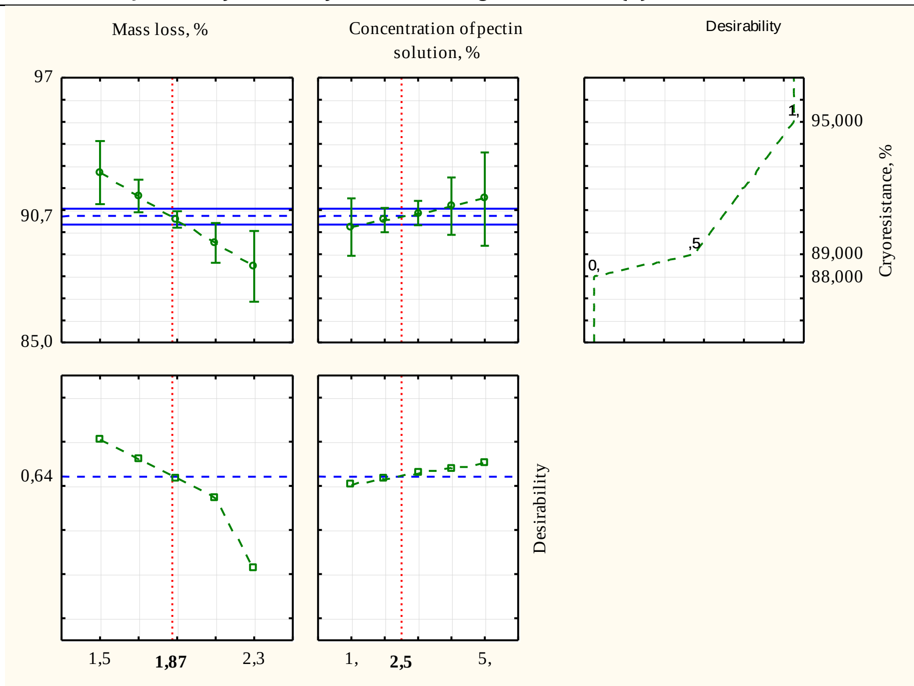
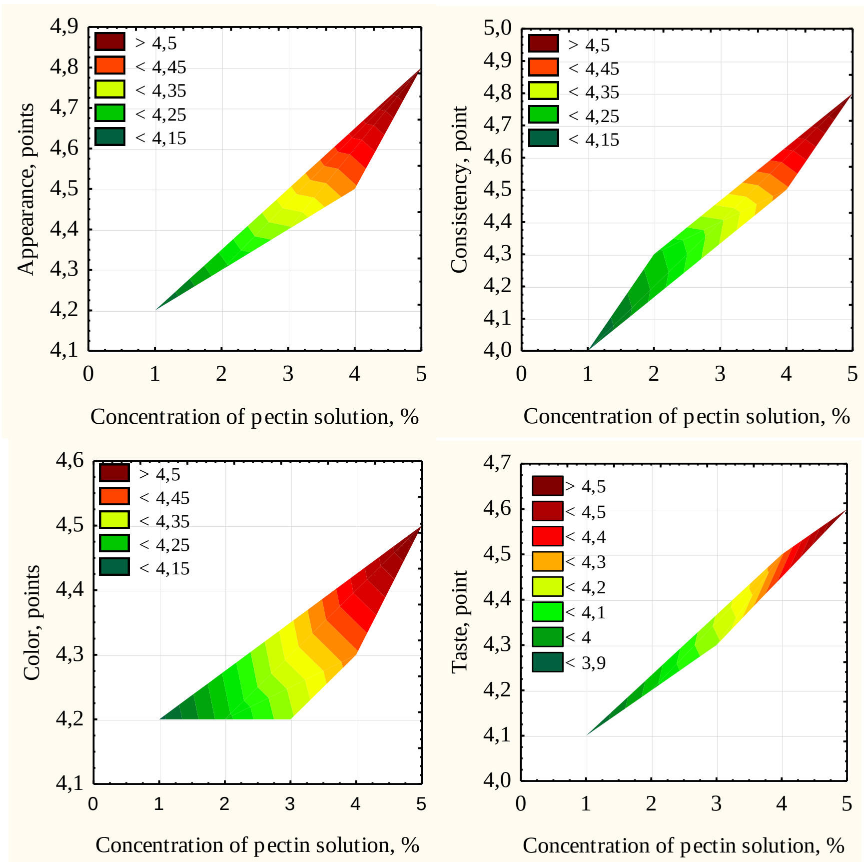


Fig. 5. Profile of predicted values and desirability function for cryoresistance of frozen semi-finished apple products depending on weight loss and concentration of pectin solution

The food-grade polysaccharide coating had a positive effect on the appearance and consistency of the semi-finished products, which were rated 1.6–1.8 points higher than the control. Somewhat lower scores were obtained for the taste indicator – the excess compared to the control was 0.9 points. However, the color and aroma of the products were not affected by the coating.



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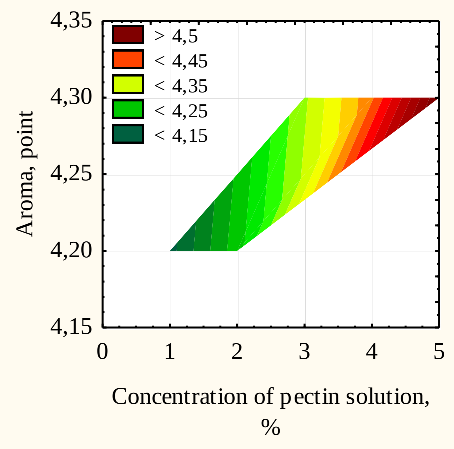

Fig. 6. Organoleptic evaluation of partially osmotically dehydrated frozen semi-finished apple products: a – appearance, b – consistency, c – color, d – taste, i – aroma

According to the results of the tasting, the maximum score for all organoleptic indicators was obtained for semi-finished products with food coating in a pectin solution 5 % concentration – 4.2–4.8 points.

Conclusions

The obtained results allow us to conclude that the application of a food coating from a pectin solution to apple semi-finished products before partial osmotic dehydration and freezing inhibits the increase in dry soluble substances during dehydration by 1.4–2.0 % compared to uncoated samples, increases cryoresistance by 0.8–7.9 % and its preservation during the storage period, reduces weight loss by 0.2–0.4 %, dry soluble substances by 0.2–0.4 %, improves the appearance and consistency of semi-finished products. To maintain the cryo-resistance of frozen apple semi-finished products over 90.7 %, their weight loss should be below 1.87 %, with a pectin solution concentration of at least 2.5%. Semi-finished products with a food coating in a pectin solution of 5 % concentration are of the best quality.

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